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ABSTRACT

A pair of interactive computer-student dialogs developed for use primarily with elementary and high school teachers are described. The dialogs use graphic facilities for teaching about the sky as seen from the earth and about the phases of the moon. The primary aim is for the teachers to understand the nature of a scientific model, in this case the model of the phases of the moon, through a Socratic interaction with the computer. The dialogs are also being used by other university students. (Author/SK)

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TWO NEW GRAPHIC COMPUTER DIALOGS FOR TEACHERS

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Abstract

We describe a pair of interactive computer-student dialogs developed for use primarily with elementary and high school teachers. The dialogs use graphic facilities for teaching about the sky as seen from the earth and about the phases of the moon. The primary aim is for the teachers to understand the nature of a scientific model, in this case the model of the phases of the moon, through a Socratic interaction with the computer. The dialogs are also being used by other university students.

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Introduction

A major problem in teaching science at all levels, particularly pre-university levels, is to bring students to an understanding of the structure of science--the nature of scientific theories, the evidence for these theories, and the mechanism for relating the terms of these theories to experience. Too often science appears to students as a series of pronouncements from on high, somehow magically true, or a series of isolated "facts." Thus, the students in introductory courses are likely to preface something which cannot, they think, be doubted, by the phrase "scientists say ...."

Some problems at the elementary and high school level arise because teachers view science in just this way. Thus, the notion that scientific theories require experimental evidence to support them, that we can employ scientific models to make an infinite number of predictions, that theories have logical structure, that operational definitions are needed to connect terms in theories with laboratory experience--all these are notions that are too often foreign to the teacher. Not surprisingly, therefore, the students acquire false notions of the nature of science.

Giving teachers new curriculum material will not necessarily overcome this handicap, even if that material reflects reasonable attitudes, as recent experience clearly indicates. Summer institutes and other retraining programs can reach some small percentage of the teachers involved, but this number is indeed negligible as compared with total national needs. Given the major role of science in shaping contemporary society and given the magnitude of the problem of reaching very large numbers of teachers

in the country, the problem is important; but current modes of teacher education appear to be inadequate to make a large impact.

It seemed to us that computer-student dialogs, interactions of students with a computer program, might assist in this particular situation. As a tentative first step, to gain experience with the technique, we have prepared the pair of computer dialogs described in the present paper. The computer used was the Xerox Sigma 7 at the University of California, Irvine, and the terminals are Tektronix 4010 and 4013 graphic displays. The software for creating such interactive student-computer dialogs was developed by the Physics Computer Development Project at Irvine.[1]

Both elementary and high school teachers used these dialogs in institutes at the University of Washington during the summer of 1973, and one of the dialogs, LUNA, has been rewritten based on the experience gained, to be described later. The dialogs require graphic terminals which draw pictures under computer control, as pictorial information is an integral part of the learning experience presented. Once effective dialogs are available, they could conceivably be utilized on a nationwide basis with large numbers of teachers.

Although not written primarily for direct student use, the two dialogs are also proving useful for high school and college students. They are self-contained, demanding little previous background. They are also in use in several other locations with similar computer equipment. The continually decreasing cost of computers suggests that such material will be much more widely available in the near future.

TERRA

The first of these dialogs is called TERRA. This dialog is a preparation for the second dialog, and may not be needed by everyone. It considers the problem of getting the teacher-student to think about how the sky looks as viewed from the earth, both during the day and one evening, and over many nights. It also carefully introduces requisite vocabulary for use in the later dialog LUNA. It is quite possible that an observant teacher, with some knowledge of what happens in the sky, could bypass this dialog entirely. If difficulties arise in LUNA, the teacher may study TERRA.

TERRA tries to draw on simple information already known to students, hopefully, based on their own observations of the sky during the day and at night. Experience indicates, however, that many teachers, particularly elementary teachers, will have only the vaguest notion of what does transpire in the sky. Hence, if the teachers cannot respond to the request from the computer for information, it may be necessary to tell them certain things and try to persude them to more active observation of the world around them. We do not introduce terms until the ideas and experiences on which they are based are clear. As with other dialogs, the experience of using the dialog will be different for different students.

This dialog deals with operational definition of terms such as "noon," "midnight," "north-south," "vertical," "zenith," "celestial and terrestrial meridians," "celestial and terrestrial poles," "celestial and terrestrial equators," and "latitude and longitude."

LUNA

The second of the two dialogs is concerned with developing and understanding a scientific model, the model that accounts for the phases of the moon. The emphasis is one of the notion of a model in general, in addition to the formation and use of this particular model. The program is a self-contained, self-study unit in the sense that it provides both the learning material (in the earlier part of the dialog) and a randomly selected quiz at the end of the unit. The teachers recycle through the material if they do not do sufficiently well on the quiz, and then they repeat the quiz. As indicated, the quiz is selected by the computer from a large pool of questions available within the program. Thus, the unit might be described as a PSI or self-paced unit, with the computer playing the role of tutor both in assisting the student in learning and in giving the unit test at the end.

The opening passage of LUNA is shown in Figure 1. LUNA starts by determining if the student is already familiar with the phenomena and the common terminology for describing the phases of the moon, such as crescent, half moon, and full moon. Figures 2 and 3 show the flavor of the early section. The student input comes each time after the question mark at the beginning of the line. The information, including the drawings is generated by the computer. Different student responses would, in general, elicit different computer-produced messages and pictures, so one set of samples like this does not by any means exhaust the range of the program.

Quite near the beginning of the program we try to find if teachers already have some notion of the model for the phases of the moon, in terms of the simple geometry involved. We do this by allowing them to point to the sun, using the graphic pointer built into the terminal, in the case where the observer on earth sees a full moon. Figure 4 shows how the screen looks to the students when this concept is first presented to them. The observer is represented by the small box on the earth. Several responses are indicated in Figures 5, 6, 7, and 8.

The program, as always, recognizes not only the correct responses, but also those wrong responses which would elicit an immediate comment from an instructor talking directly to the student, carrying on the same type of Socratic dialog.

LUNA continues in the same vein. It considers not only what happens in one night, but also covers the full cycle of the moon's waxing and waning. It also tries to get students to make the connections, implied by the model, between the rising and setting of the sun and the moon in the various phases. Thus, we stress the predictive power of the models. As far as possible, students are urged to generate the necessary connections, often with hints provided in multiple tries; we try to avoid the presenting of information directly to the students.

Preparation of Dialogs

Since the generation of student-computer dialogs is still a relatively new experience, it seems appropriate to discuss the authoring system used in the present case, as an example of one such preparation.

Work on the two dialogs started during the Christmas vacation in 1972, when both of us were together at the University of California, Irvine. The initial day of our two weeks together went into deciding what type of computer material we intended to write; although we had discussed this in the past it was far from a resolved issue. We decided to write the two dialogs indicated in the remainder of the two-week period, although several other possibilities were also actively considered.

We proceeded by generating loose flowcharts showing the form the dialog was to take, indicating the pictures by verbal descriptions. These hand-drawn charts were on large sheets of paper, and indicated the pedagogical details. At this stage the computer played little role. We were working as teachers, trying to decide what students are likely to say in response to a particular question, and what sorts of responses should be given for various replies the students might give. One of us worked full time, the other about half time, so about one-half week was needed at this stage for each dialog.

This way of working does not produce neat material, but it does produce material in sufficiently good form to go to a secretary. We have secretaries trained to sit at the terminal and enter, using the editor in the computer, much of the code required to support the dialog just indicated. The secretary can successfully do about 90 percent of the typing required, and can do it much more effectively than a programmer, student, or professor can do it under these circumstances. We have not found the training of secretaries to be a difficult issue. In this case the

material was typed by Anna Tartaglini of the Irvine Physics Department; she spent about two weeks at the terminal, interspersed with other work.

In the next stage the material goes to an undergraduate programmer who can fill in the parts the secretary omitted and can generate the initial running version of the program. The programmers associated with TERRA were Hal Deering and Dobree Purdy, and John Collins was responsible for LUNA. Although the secretary has done 90 percent of the typing, this turns out to be only about 10 percent of the actual coding. The major problem lies with graphics. The programmer must still construct the graphic material in a relatively careful, slow fashion, and this is time consuming. The programmer at this stage, working with the instructor, can trace down and eliminate many programming errors--bugs--in the teaching program. Each dialog required about two weeks of programming time, spread over a period of about two months.

The first running versions of these dialogs were available in March. These versions still had many bugs in them, due to both oversights on the part of the authors and to programming problems, particularly in constructing the graphic material.

Several students in the elementary education program at Irvine were kind enough to test the dialogs at this stage, running the programs to help us find likely problems associated with them. We also used the programs as demonstrations with visitors, and used them to some extent also with our own students.

At this point the program is changeable, going through many variations as new errors appear. Some of these are in the nature of cosmetic details--such as clearing up places where the writing

overlaps the picture--while others uncover programming errors which would make the program unusable with sizable numbers of students. After several months of such informal testing a relatively "stable" version was available.

Initial Use

As indicated above, the two programs were first used on a sizable scale with teachers at the University of Washington during the summer of 1973. Two different institutes were involved--one with elementary teachers and one with high school teachers.

At least three types of information were secured in connection with the use of the program with teachers. First, the instructors watched what was happening and talked with the students, and so formed impressions about the effectiveness of the use and the problems. Second, the teachers in the institutes were asked to comment on the programs, and we received a series of quite detailed written comments from the high school group. Third, the programs gathered information as they were run, storing such information in computer files. What is saved is dependent on the author; we saved primarily information on what responses the computer could not analyze and also information on what parts of the program were used.

As expected, this testing revealed a number of specific weaknesses in the program. One difficulty was the omission of any facility for teachers to review a section after having gotten through it, even if their grasp might still be shaky. The length of the program constituted another difficulty. LUNA requires about 90 minutes, TERRA about 60. Students often found the

programs exhausting, yet unlike college students who have used dialogs, were reluctant to use the restart facilities which allow the student to come back in at a later time.

Timing considerations were found weak. The computer often pauses to allow time for reading, but the timing of these pauses needed tuning, particularly in changing pages (erasing the screen), and the students needed to be given more control over the delays in the program.

The responses saved by the computer are extremely valuable in making the next version of the program more responsive, after these are sorted in the appropriate way. Thus, the next generation of the program can be more interactive with students, present fewer problems, and also be more effective in promoting learning. Previous experience with dialogs suggests that an order-of-magnitude improvement can be made by careful examination of the answers students are giving.

A major problem came up for the elementary teachers in the use of LUNA. LUNA proved to be too difficult for many of these teachers, assuming more background information than they actually knew. On the other hand, LUNA proved reasonably effective, particularly for the first try, with the high school group. It may be necessary to get students started by personal discussion and holding objects out in three dimensions, and noting the shadows. We did not follow this sequence, but plunged them directly into the dialogs, hoping this would relieve us of the usual start-up.

New Version of LUNA

Based on this information, we have prepared a second version of LUNA. The programmer has been Craig Taylor. In addition to

meeting the problems indicated by saved responses, the new version allows the student to review previous material, and it allows student control over the timing on delays. This version is in use by Irvine students. It is particularly popular with students not taking physics classes, and is employed widely in demonstrating the Physics Computer Development Project material to visitors; this background use amounts to about 2,000 terminal minutes per month. TERRA, and the new version of LUNA, are available also at a number of other schools with Xerox equipment.

Future Use

Computer dialogs such as TERRA and LUNA are currently available at only a few schools, primarily because only a few schools are currently dedicating considerable interactive computer use to learning. Hence, developers of such material cannot expect immediate large-scale availability similar to textbook availability. But such availability is likely in the long run. Prices of computers continue to decline, and so computer-based learning materials will be more and more competitive in cost. So the potential exists for such dialogs to be used very widely with students. It is not likely that this potentiality will be realized, however, until a larger body of well-tested dialogs has been developed.

Slides of LUNA and TERRA are available, and remote demonstrations of these and other dialogs developed at Irvine can be arranged. Program listings or tapes are available for those schools having access to Xerox computers.

Reference

1. A bibliography and other documentation are available from Alfred Bork. The project is supported by the National Science Foundation and the University of California.